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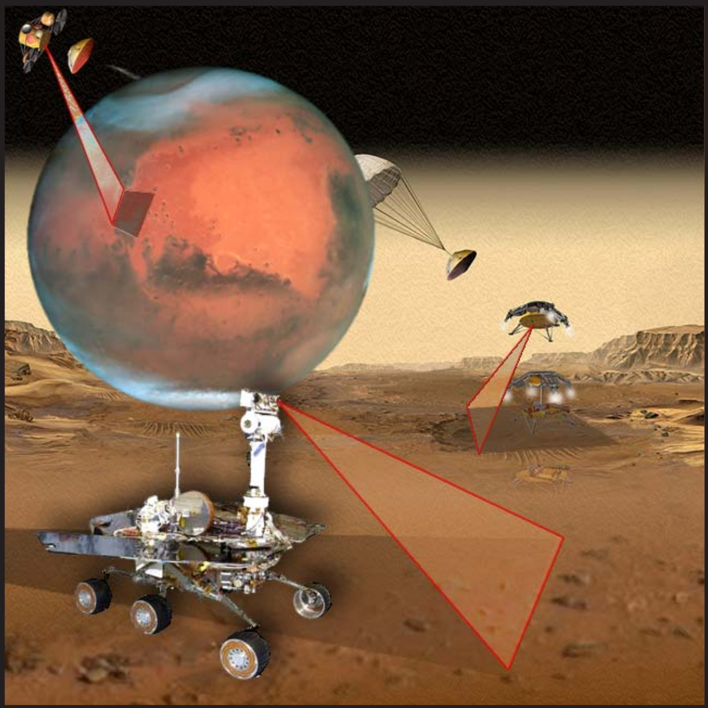
GODDARD TECH TRENDS

Goddard Technology Management Office — Goddard Space Flight Center

Inside:



Goddard technologists are working on laser instrumentation that will characterize the Martian atmosphere and improve landing safety on Mars and other solar system bodies.

1 Goddard Investigators Win Exploration Systems Research and Technology Funds

Two Goddard researchers have received funding from the NASA Exploration Systems Mission Directorate to carry out two separate investigations involving laser technology.

Both received funding under the directorate's Exploration Systems Research and Technology (ESRT) program, which promotes the development of revolutionary system concepts, architectures, engineering tools, communications networks, and other breakthrough technology necessary for robots and humans to explore destinations in low-Earth orbit and beyond.

Laser 3D Vision

William Heaps, the head of Goddard's Laser and Electronic Optics Branch, is investigating the best methods for obtaining 3D vision with a laser altimeter, an instrument that NASA has used to map the surface of the Earth, Moon and Mars. With 3D vision, scientists would receive their data as a two-dimensional image — similar to a photograph — and the exact distance from the instrument to any point in the photograph. Three-dimensional vision provides the distance information.

Currently, technologists have successfully used two different methods for operating a 3D vision system in Earth-based applications (see sidebar on page 2). Heaps is evaluating these approaches for use under a variety of mission scenarios. Ultimately, he hopes to develop the capability to use 3D vision in space.

The investigation will examine the technological maturity of components necessary to implement a space-borne laser-vision device, including a variety of lasers,

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scanners, detectors, and other components needed to build a complete system.

Laser/Lidar Technologies for Exploration

David Tratt, a program manager for the Earth Science Technology Office, will lead a team of Goddard and NASA Langley technologists and scientists in a laser/lidar technologies investigation. The goal is to increase overall confidence in space-qualified laser hardware, which the NASA Exploration Systems Mission Directorate has identified as critical for assuring mission success in the future.

Tratt's team plans to develop and formulate a series of design and handling procedures as well as component-screening protocols. They also plan to establish brass board laser systems for critical 1- and 2-micron wavelengths. These would serve as operational testbeds for the space-qualification techniques and protocols developed under this effort.

Getting a 3D Vision Image

Engineers have found two different ways to operate a 3D vision system. Under one method, the instrument transmits a laser beam and records how long it takes for the beam to reflect off the target. The instrument is then pointed in a slightly different direction and the process is repeated. With the second, the pulsed laser beam is spread out optically so that the laser immediately illuminates a large area. Again, the instrument measures the reflection's time of arrival, but here an array of individual detectors accomplishes the task with a single laser shot. Engineers have successfully used both methods for Earth-based applications.

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2 First Applied Nanotechnology Device to Fly in Space in 2005

Quantum Chemical Sensor Delivered for Integration

In exchange for helping the U.S. Naval Academy develop its Midisat spacecraft, Goddard technologists will be able to fly one or more technology demonstration projects on the craft when it flies aboard a Delta rocket in September 2005.

One of those demonstration projects will be a prototype Quantum Chemical Sensor (QCS), which Ames research scientist

"This is a powerful and sensitive detection method. Given the extremely small size of the individual nanotubes — less than 10 nanometers in width — and the quantum nature of the sensing principle, Dr. Li's prototype constitutes a true applied nanotechnology development."

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A Delta launch vehicle will fly the world's first nanotechnology demonstration project in 2005.

Jing Li recently delivered to the Naval Academy for integration into Midisat, said Dan Powell, lead Goddard nanotechnologist and coordinator of the flight demonstration. "This collaborative flight development will culminate in the first flight applied nanotechnology in space," he added.

William Smith, a professor at the Naval Academy, is overseeing the development of the MidiSat spacecraft.

Li's device senses by noticing a change across a bed of nanowires or carbon nanotubes (CNTs), which technologists have connected to electrodes. Since the device contains literally millions of carbon nanotubes, very small changes are parallelized, inducing a global resistance change across the array. This change is sensed and then registered through the amplification of the signal.

"This is a powerful and sensitive detection method. Given the extremely small size of the individual nanotubes — less than 10 nanometers in width — and the quantum nature of the sensing principle, Dr. Li's prototype constitutes a true applied nanotechnology development," Powell said.

Analysts believe the chemical sensor market will grow to more than $40 billion worldwide within the next 10 years. Nanostructured chemical sensors can be used to monitor and control environmental pollution, improve diagnostics in medical care, reduce power consumption in industrial applications, and improve the detection of Homeland Security and environmental threats on the battlefield. In each of these applications, a demand exists for improved sensitivity and selectivity beyond what is currently commercially available.

The emerging field of nanotechnology also can play an important role in space science, Powell said, and Goddard will be among the first to take a significant step in that direction by having provided Li with the opportunity to fly the QCS in space.

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3 NASA to Demonstrate Autonomous Fleet of Aquabots this Summer

Getting in-situ measurements of ocean surface winds, air temperature, salinity, color and currents is often easier said than done. However, a new platform system now under development at Goddard and the Wallops Flight Facility promises to make data gathering easier and less expensive to do on the open seas, say Goddard technologists.

Under a joint NASA/NOAA-funded effort led by Wallops oceanographer John Moisan, the NASA team is developing six low-cost, fully instrumented platforms that will be able to autonomously and collaboratively gather near real-time observations of various ocean phenomena.

Currently, scientists rely on stationary or drifting ocean buoys to obtain in-situ measurements. These platforms degrade quickly, are expensive to maintain, and cannot track dynamic science events autonomously.

NASA's new platform system, called the Ocean-Atmosphere Sensor Integration System (OASIS), promises to give scientists the capability to select a target or scientific goal based on near real-time data analysis and predictive modeling and to carry out observations with little human oversight. They also offer the advantage of being relatively inexpensive ($20,000 per boat) and easily calibrated and repaired because they are mobile and return home.

OASIS boats can operate independently, or can be controlled by Goddard's Adaptive Sensor Fleet (ASF) technology, a dynamic, collaborative measurement software system that has broad applications to other NASA initiatives (see sidebar on right). With this specialized computer software system, scientists identify their target and the system's "fleet manager" divides the work and directs each platform to the site depending on the current location of the target, currents, obstacles and the location of each platform. On a computer monitor, ASF then displays the progress of each platform and the cumulative scientific data gathered as the boats progress.

The NASA-developed aquabots promise to make data gathering easier and less expensive to do on the open seas.

The Versatility of ASF

Goddard's Adaptive Sensor Fleet (ASF) technology has wide use in a number of applications. Integrated into an OASIS-type ocean-faring platform, it can help scientists track hurricanes and predict where they might make landfall or gather in-situ measurements needed for predictive modeling, says ASF project manager Jeff Hosler. It also could be used for missions to the Moon or Mars as part of the new Vision for Space Exploration. In addition to demonstrating the technology in the OASIS program, Hosler's group is making plans to show the technology's utility using land robots developed by Carnegie Mellon University in 2005.

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OASIS: A Next Generation Platform

Specifications for the ocean-faring platforms now under development at Wallops are quite precise. The vehicles must:

- Run under solar power for up to 3 months at a time and cost no more than $20,000 to build.
- Move through the water continuously at a surface speed of 2 knots, which is 10 times faster than the mean observed ocean currents.
- Offer real-time, two-way communication capabilities to transmit and receive data and commands between the vehicle and the command center.
- Be small enough to be deployed from a small coastal research craft and maximize the use of off-the-shelf parts.

"The real advantage is that the system can gather better science data than could be gathered previously," says Jeff Hosler, ASF project manager. "The system can optimize the science collection process."

To illustrate, Hosler uses the example of an algal bloom. Ocean currents and other physical phenomena will change the boundaries of these blooms. To get an accurate reading, scientists need the capability to move with the target and to select and carry out new scientific objectives mid-stream. That's where the ASF fleet manager comes into play. Goddard technologists have designed it to analyze data and to redirect the boats as needed.

Under current plans, the Goddard team hopes to test the platforms traveling independently from one point to another in a demonstration this summer. In this test, researchers will drop dye into the ocean and the platforms will map the dye using in-situ data points.

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A Brave New World

Software Defined Radio Offers New Functionality

Goddard technologists are laying the foundation for an SDR-enabled NASA and they're looking for a few good partners to bring this vision to fruition.

SDR stands for Software Defined Radio, a wireless technology that gives an electronic device the ability to quickly and easily perform new functions on demand. With SDR, manufacturers could install a generic radio chip into any device and later "educate" it to do something quite different through a simple software download.

Similarly, engineers could reconfigure future SDR-enabled NASA orbiters at will, allowing formerly independent satellites to be linked to give a more complete picture of a unique scientific

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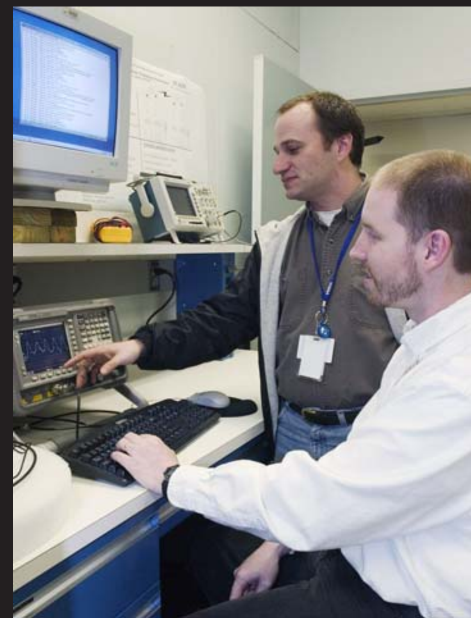
event. In other applications, two satellites could interact and share information or an older satellite could be updated with a new function and mission, extending its life and usefulness.

Goddard has built an SDR testbed that provides the necessary foundation for investigating SDR technologies and techniques. This testbed allows for the rapid, low-cost development of communication and navigation algorithms that will be used in upcoming technology experiments, and eventually, in missions. The first SDR components should make spaceflights within the next 3 to 5 years — around the same time experts believe that everyday devices could start becoming SDR-enabled, said Jason Soloff, an SDR technologist.

One of the main goals of Goddard's SDR testbed is to allow NASA to work with industry to seed new SDR technologies. Another is to create partnerships with others working on SDR. If you would like to partner with Goddard or use the SDR testbed, contact Soloff.



Goddard technologists work in the SDR testbed.

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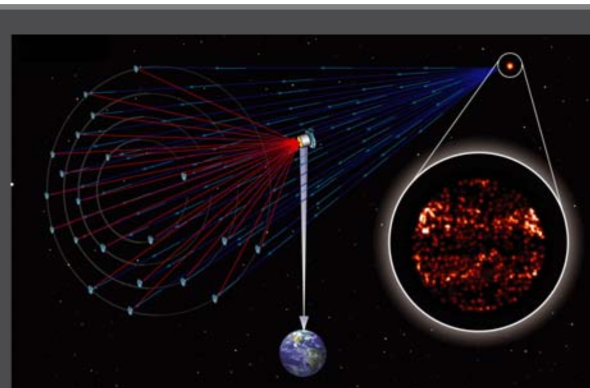
5 Formation-Flying Testbed Continues to Expand Capabilities

The testbed facility used to develop, test and integrate relative navigation algorithms and sensors, formation design and control algorithms, and other technologies critical for developing formation-flying spacecraft is adding capabilities to support additional science and exploration applications.

Technologists plan to integrate an air-bearing table, which will support hardware in-the-loop verification of distributed sensing and metrology technologies. In addition, the facility has completed the first phase in the development of an inter-satellite communications channel simulator, which technologists will use to incorporate spacecraft-to-spacecraft communications hardware into the formation-flying loop.



The proposed Stellar Imager is just one of many missions considering the use of formation-flying technology.

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Why Formation Flying?

To image black holes and planets or perform asteroseismology, scientists need many orders-of-magnitude improvement in angular resolution compared with today's state-of-the-art — the Hubble Space Telescope. Size limitations on launch vehicle fairings, however, restrict the achievable aperture size required by many of these mission concepts. The only way to achieve the many orders-of-magnitude improvement in resolution is through formation flying, says Jesse Leitner, Goddard's lead engineer for distributed space systems. The idea, he said, is to fly many satellites in close collaboration and tight control to create a distributed segmented telescope or interferometer. "For the most part, component technologies are at a high level of readiness for very challenging missions, but system-level challenges remain and significant effort is required to reduce risk," Leitner said.

The testbed facility, located in Building 11 and operated by the Mission Engineering and Systems Analysis Division, supports multiple missions and is equipped with a modular software infrastructure, simulated flight processors, GPS receivers and signal simulators, and other hardware and software needed for integrating component technologies to enable formation-flying spacecraft.

Several formation-flying spacecraft missions are planned for launch in 2009 through 2025, including the Magnetospheric MultiScale Mission, the Terrestrial Planet Finder-Interferometer, the Stellar Imager, MAXIM, the Solar Imaging Radio Array, and the Submillimeter Probe of the Evolution of the Cosmic Structure.

In addition, formation-flying technology is one of five in contention for the New Millennium Program's ST-9 demonstration flight in 2008-2009. Significant work is taking place in the testbed to support the proposed ST-9 demonstration.

The testbed capabilities also are being integrated to support the Hubble Robotic Servicing and De-orbit Mission.

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Goddard Tech Trends is published quarterly by the Goddard Technology Management Office (Code 502) at the Goddard Space Flight Center in Greenbelt, Maryland. The newsletter describes technology developments at the Center and explains how they are helping NASA to achieve its mission. If you wish to be placed on the newsletter distribution list or if you want more information about Goddard technology or the Goddard Technology Management Office, contact:

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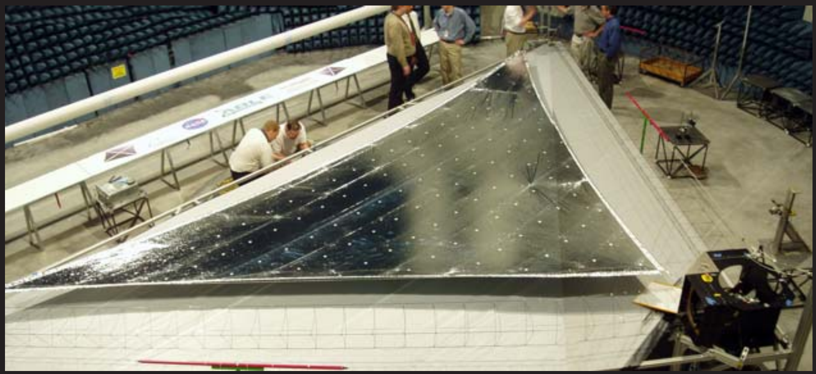
6 Worth Noting

Goddard technologists successfully demonstrated the value of **sensor web** measurement techniques using two Earth Science satellites that fly in formation (*Goddard Tech Trends*, Fall 2004, Page 3). During the demonstration, which took place in early November, **Stephen Talabac** and his team ran a very fast algorithm on real-time, direct readout data from Aqua's MODIS instrument to determine which of 15 previously selected metropolitan areas were cloud-free. With that information, they then simulated the targeting of Aura's pointable infrared spectrometer, TES, to take measurements of only the cloud-free targets. Since Aura is in an orbit that follows Aqua by only 15 minutes, the challenge was to receive and process the Aqua data in real time. Sensor webs allow different data-gathering platforms to behave as a single, dynamic observing system. For more information, contact Stephen Talabac at 301-286-1452.

Minoo Dastoor and **Murray Hirschbein**, nanotechnology leads at NASA Headquarters, have agreed to host a NASA Web site to capture posters and presentations delivered at the recent Goddard-hosted **University Research Engineering and Technology Institute** Partnering Workshop and Enabling Technology Showcase held in October. Nearly 160 people attended the meeting, which showcased cutting-edge technology developments from each of NASA's four URETI partners — UCLA/Cell Mimetic Space Exploration, Purdue/Institute for Nantoechnology and Computing, Texas A&M/ Texas Institute for Intelligent Bio-Nano Materials and Structures for Aerospace Vehicles, and Princeton/Biologically Inspired Materials Institute.

Ninety-five people attended the **Solar Sail Technology and Applications Conference** in Greenbelt September 28-29 to discuss recent progress in sail technology and mission concepts. Presentations by L'Garde, Inc. and AEC Able, Inc. showing recent results from a 10-meter deployment drew considerable interest. "Those attending the conference saw abundant evidence that the solar sail has advanced well beyond mere concept and the limited ground tests of the past," said **Timothy Van Sant**, co-chair of the conference organizing committee and a technologist for the Sun-Earth Connection Program.



Solar sail technology has advanced beyond concept and limited tests, Goddard technologists say.